EFFECTING URBAN TRANSPORT SYSTEM RESILIENCE THROUGH INTEGRATION OF COMMUTER RAILWAY SERVICES, A CASE OF MWIKI, NAIROBI

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ABSTRACT

Sub-Saharan Africa population is expected to increase by 129% in 2050 basing in the year 2010. Rapid population growth coupled with urbanization and industrialisation, creates extreme travel demand and high car ownership which, are the primary factors of congestion in urban roads. Congestion has manifold adverse effects on commuters, environment and general city's inhabitants, counting high costs of travel, high commuter stress, prolonged travel time, high energy consumption, physical inactivity, increased carbon emission, working hours, noise pollution, delivery time, labour costs, constrained economic productivity, general people's quality of life, adverse health and environmental externalities. The situation is escalated in extreme weather. Governments have made continual attempts to improve existing road infrastructures to solve the mobility snag, however they have borne trifling results. Road transport in isolation cannot be able to solve this peril. Hence, the necessity of integrating commuter rail services in Nairobi Transport System, so as to enhance traffic flow in the existing roads. Nairobi railway commuter railway services have been in existent since early 1990s, but they have not been embraced by most Nairobi City County commuters, ascribable to multifarious glitches such as overcrowding within the train wagons, which provides an environment for some anti-social behaviours; lack of instantaneous communication systems; poor accessibility to railway stations; unreliability; breakdowns of locomotives; low train speed, inadequate social amenities, inadequate parking spaces among others. This can be solved by providing users with efficient, reliable, seamless, multimodal services, which will augment train modal split and, in the process, solve the congestion puzzle.

Keywords: *Inclement weather, integration, resilience, traffic congestion, transportation system*

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1 INTRODUCTION

All facets of city's life together with its viable progression and opulence is greatly shaped by transport [1]. An efficient transport system stimulates socio-economic development, since it influences the growth of economic activation, development of production, trade, and all kinds of services [2], [3], [4]. Transport systems experience cyclical stresses, the prevalent ones being traffic congestion and accidents; and shocks such as flooding and earthquakes [3], [1]. Urbanisation and population increase in developing countries, augment transportation demand and pressure in existing urban transport systems [5]. Rapid population growth coupled with urbanization and industrialisation, creates extreme travel demand and high car ownership, which are the primary factors of congestion in urban roads infrastructures [6], [7]. Africa Urban population is expected to reach 60% by 2050 basing the year 2010 [8], with Sub-Saharan Africa populace to reach 1.96 billion , a 129% increase in the same period [9]. Ascribed to climate change, the world is experiencing increased degree, frequency and austerity of weather events, which imperils transportation to more stern stresses and sudden shocks [1]. About ½ of the days in a typical year have weather conditions such as flooding that affect driving and contribute to road closures and traffic slowdowns. It is estimated that 15% of traffic congestion is a result of inclement weather [10]. Further, factors such as urban population size, employment agglomeration, and income also shape traffic congestion [11]. The spatial-economic structure of cities like Nairobi, where commuters attempt to access jobs and socio-economic prospects nearly solely to the Central Business District (CBD) at the same time i.e., from 8:00am to 5:00pm, also contribute to the peril of traffic congestion [12]. Amid the hurdles to sustainable transport developments, traffic jamming has been the incessant hitch [13]. It has assorted adverse effects on commuters, the environment and the general city's inhabitants, counting; high costs of travel, high commuter stress, prolonged travel time, high energy consumption, physical inactivity, increased carbon emission, working hours, noise pollution, delivery time, labour costs, constrained economic productivity, general people's quality of life, adverse health and environmental externalities [14], [15], [11], [12]. Governments have made continual attempts to improve existing roads infrastructure to solve the congestion snag. The question still remains, the menace of traffic congestion has been in existence for decades. For instance, when Thika Super Highway in Nairobi City County was upgraded from four (4) to eight (8) lanes, it was presumed to be the ideal solution in easing traffic congestion [16]. Unfortunately, it was an interim solution. The loss of productive time, money, energy, and motivation is still shouldered by commuters and the city's residents [5]. The situation is exacerbated in inclement weather. Thus, integration of other modes of transport in urban transportation system will be the panacea to this peril. Given the uncertainty of disruptive system failures, the concept of resilience describes the system ability to withstand possible perturbations and recover to an acceptable functional level.

2 LITERATURE REVIEW

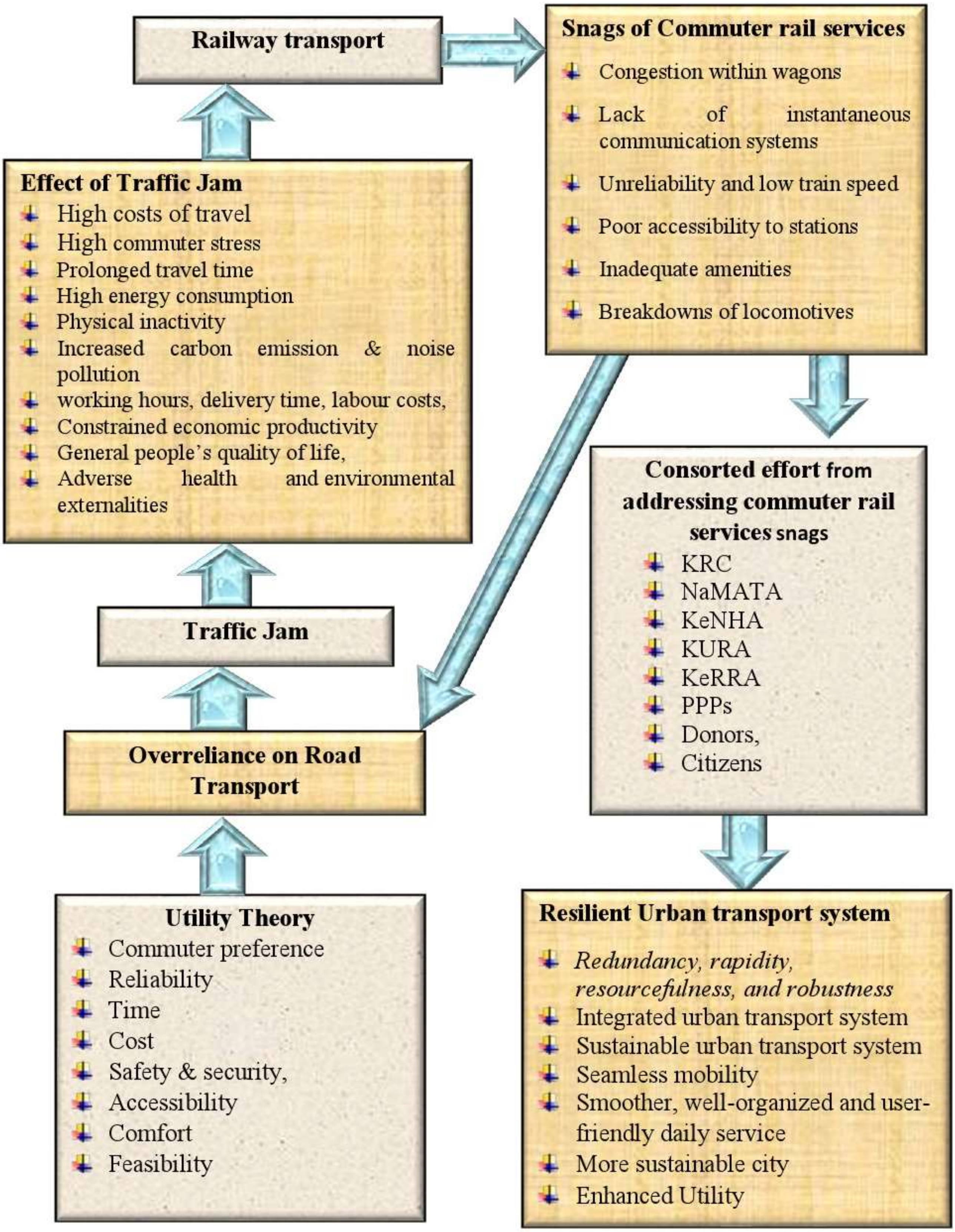
2.1 Utility Theory

Utility is the gratification that the decision maker gets from each choice, in this case is the mode of transport [17], [18]. Mobility and travel options are shaped by transportation services attributes, tendered by the accessible modes of travel, counting reliability, pecuniary costs, travel times, comfort among others [19]. In transportation, the measure of satisfaction that the commuter acquires from selecting a particular mode is referred to as the utility function (U). Mathematically, the function is represented as $U(x) > U(y)$, where option x is preferred mode over alternative y [17]. For example, the preferred mode of travel is guided by reliability, time, and cost of the accessible modes [19]. According to Wang et al. [20], passengers incessantly incline towards travel routes and modes with utmost utility. Utility theory postulates that preference is made on the footing of the utility maximization principle, where the optimal alternative is the one that offers the upmost benefit to the individual or organisation making decision [17], [21].

2.2 Resilience of urban transportation systems

Resilience depicts the systems aptitude to withstand potential disturbances and recover to acceptable operative level [22], [23], [24]. Transport resilience refers to the knack of a transport system, to prepare for and withstand, absorb and adapt to shocks, stress and to recover from the consequences in a timely and efficient manner [25]. A resilient transportation network can continue to offer seamless mobility even in the face of a changing climate [10]. Various studies have been done on what a resilient transport system should possess. First, Bruneau et al. [26], highlights 4 features of a resilient transport system; redundancy, rapidity, resourcefulness, and robustness. Redundancy signifies the degree to which there are alternative units that can serve as stand-in, and thus absorb the aftermaths of degradation. Rapidity signifies the aptitude to recover in a timely and effectual manner. Resourcefulness signifies the aptitude to detect problems, prioritize actions and amass human and essential material resources to adjust and recover the system. Robustness signifies the aptitude to withstand shocks without or with only narrow degradation of service. Second, Leobonsa et al. [27], mentions transport resilience as the ability to uphold the mobility in satisfactory levels, typified by rapidity, robustness, redundancy and resourcefulness. Where redundancy and robustness are absolute attributes of the transportation system whereas the resourcefulness and rapidity are features principally associated with the capacity to operate and manage the system. Third, Arup & Siemens [1], states that a resilient transport systems possesses an integrated multi-modal systems to instantaneous commuter and driver info systems, which can offer a platform for achieving responsiveness, flexibility, and redundancy; indispensable features of resilience. A resilient integrated transport system will sequentially offer its users with a reliable, seamless, and efficient multimodal service. Ameliorated integrated transport systems deliver a smoother, well-organized and user-friendly daily service, and also more adept to deal with the strains of sporadic shocks and stresses linked to peak demand. Improving urban transport system resilience is a novel trend in making cities more sustainable [28].

3 CONCEPTUAL FRAMEWORK



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4 RESEARCH METHODS

4.1 Design

The study sought to empirically investigate how Mwiki residents embrace the use of commuter rail services as a resilient way in addressing traffic congestion, snags and how to enhance the resilience. Mwiki is one of the populated places in Nairobi and is traversed by Nairobi- Ruiru railway line. It is also privileged to experience commuter rail services via the existing railway station. Random sampling with a sample size of 50, and participant observation technique were employed. The researcher intermittently utilised railway commuter service to and from the study area.

4.2 Data Collection

The study employed KoBoCollect in primary data collection. The enumerators downloaded the structured questions in their android phones, administered to Mwiki residents and later uploaded in the KoBoToolbox for initial analysis. As well, it was also collected through key informant interviews; observation, where the researcher intermittently utilised railway commuter service to and from the study area; and photography. Secondary data was obtained through literature review of existing relevant documents, policies, reports among other sources. Secondary data were vital in location analysis, conceptual framework development regarding the integration of commuter rail service as a resilient way in addressing traffic congestion and inclement weather concerns in urban transport systems.

4.3 Data Analysis and Presentation of the Findings

Initial simple analysis was automatically performed in KoBoToolbox when the enumerators uploaded their filled forms. Afterwards, the data was downloaded for further analysis through excel, SPSS and ArcGIS. Spatial data was analysed using GIS and presented in the form of maps whereas other descriptive data were presented through texts, tables, percentages, figures, graphs and charts. The analysis enabled further parleys and interpretation of the integration of the commuter rail services, and how the residents have embraced it.

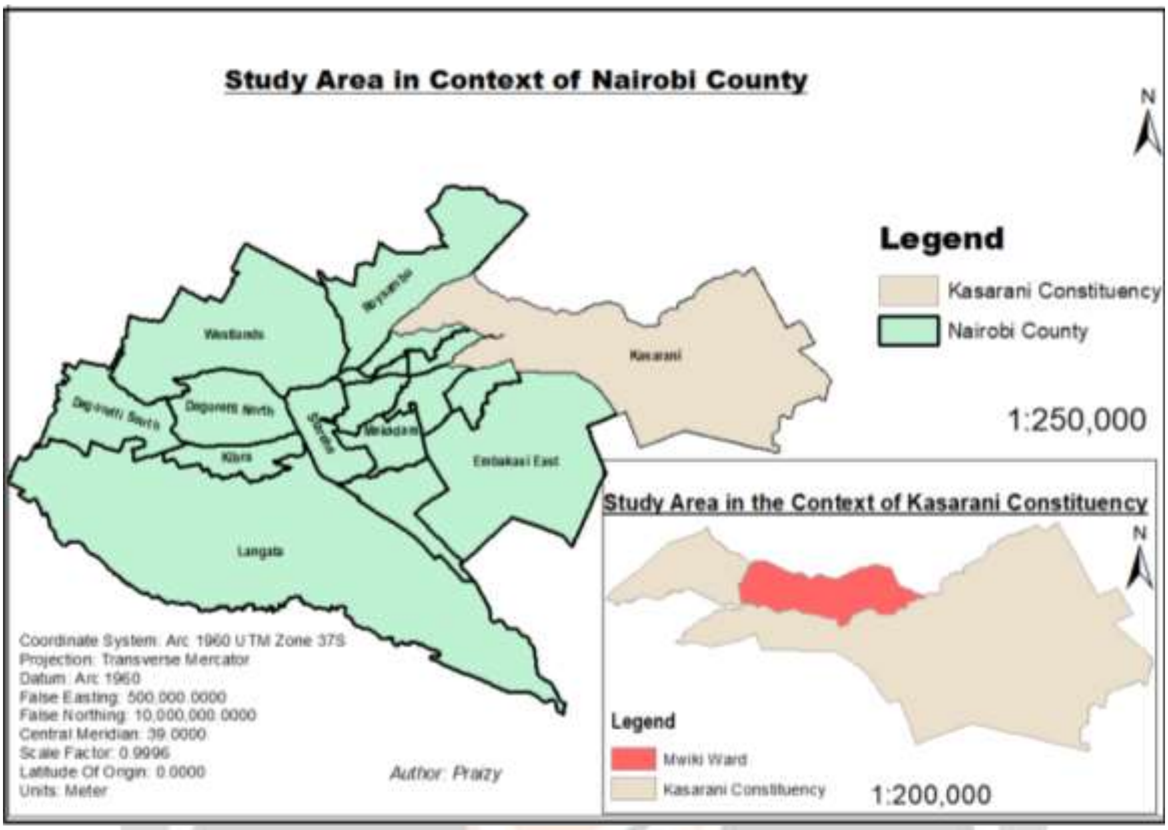
4.4 Study Limitation

Due to inadequate finances the study had to be in the confines of Mwiki, where some of its residents are proximate to the commuter rail station.

5 RESULTS

5.1 Background of the study area

The study area is located in the North Eastern side of Nairobi City County and in the North East of Kasarani Constituency, which has the highest population after Embakasi Constituency in the county. It has an approximate population of 780,656 [29]; and its annual population growth rate is expected to reach 4.1 by 2023 [30]. The stretch of the study comprises of land uses such as residential, transportation, agriculture, commercial, public utility, industrial, educational, public purpose, and recreation. The map below shows the locational context map of the study area;



Map 1: Mwiki Ward in Nairobi County and Kasarani Constituency Contexts

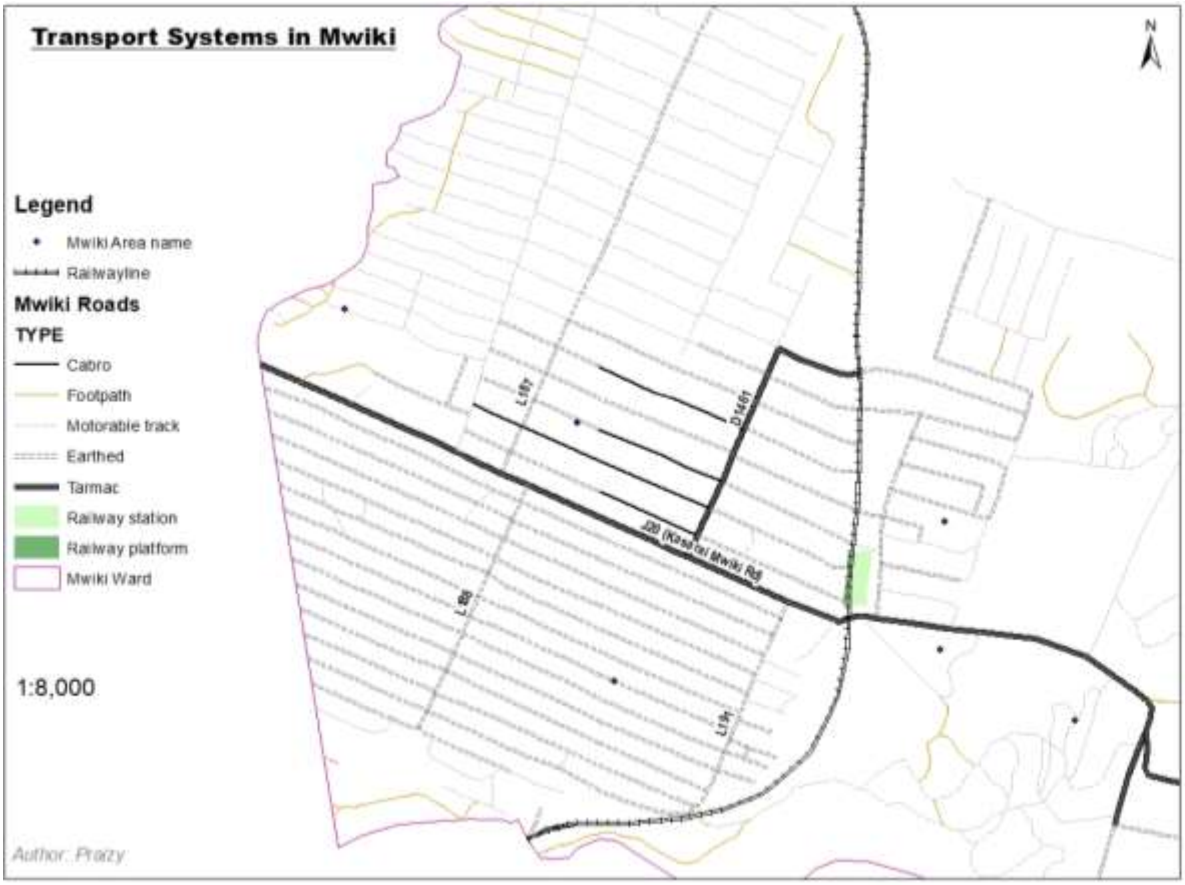
5.2 Transportation Systems in the Study Area

5.2.1 Road transport

Kasarani-Mwiki road a class B urban road (J20_Nairobi) initially a class D400 road, is the major road serving the area. It is a link between Thika road (A2) and Kangundo road (B63), hence it channels traffic between the two roads. As well, it is connected to interior feeder roads such as St. Dominic Catholic Road (D1461), ACK road and innumerable class E roads such as L187 and L188 roads. Kasarani Mwiki road is tarmacked and mostly congested. A few of the feeder roads have cabro with a significant proportion being earthed.

5.2.2 Railway transport

The study area is traversed by Nairobi-Ruiru railway line. It is privileged to have a railway station where the commuters are picked and dropped.



Map 2: Transport system in Mwiki

5.3 Commuter Rail Services in the study area

The area boasts of commuter rail services since it has an operative railway station along the Nairobi-Ruiru Railway corridor. Presently, this route is served by a 24-coach train, which has a capacity of 3168 with 1488 seated and 1680 standing passengers i.e., 62 seated and 70 standing passengers per coach. Commuter rail services are operated by Kenya Railways Cooperation (KRC). The train makes two trips in the morning to town and one trip from town in the evening. **Table 1** details the train schedule for commuter rail service to and from the study area. The early morning (6:40am) train is stabled at Ruiru at night whereas its locomotive return to Nairobi the main station. The locomotive goes back to Ruiru in the morning for the train. It then picks passengers from Ruiru and from assorted stations along the Ruiru corridor to the CBD. As well, it is worked from Nairobi to Ruiru while dropping passengers at various stations until it gets to Ruiru. Thereafter, the locomotive returns to Nairobi for the next Cycle in the morning.

Table 1: Train Schedule for Commuter Rail Services to and from Mwiki

Route	**Mwiki-Nairobi Main station**	**Mwiki-Nairobi Main Station**	**Nairobi Main Station-Mwiki**
Time	6:40 AM-7:35AM	9:20-10:15AM	17:40PM-18:36 PM
Peak/ Off-peak	Peak hour	Off peak	Peak hour

5.4 Rating Commuter Rail Services in Mwiki

As illustrated by **figure 1**, a significant number (58%) of commuters rated commuter rail services averagely. They feel there are improvements to be considered in the service provision. 33% rated the services as good, only a few upgrades to be made for efficiency. 6% rated the services as bad, they feel massive enhancement is needed in the service provision, whereas the remaining 3%, rated the service excellent, they are contended with the status quo.

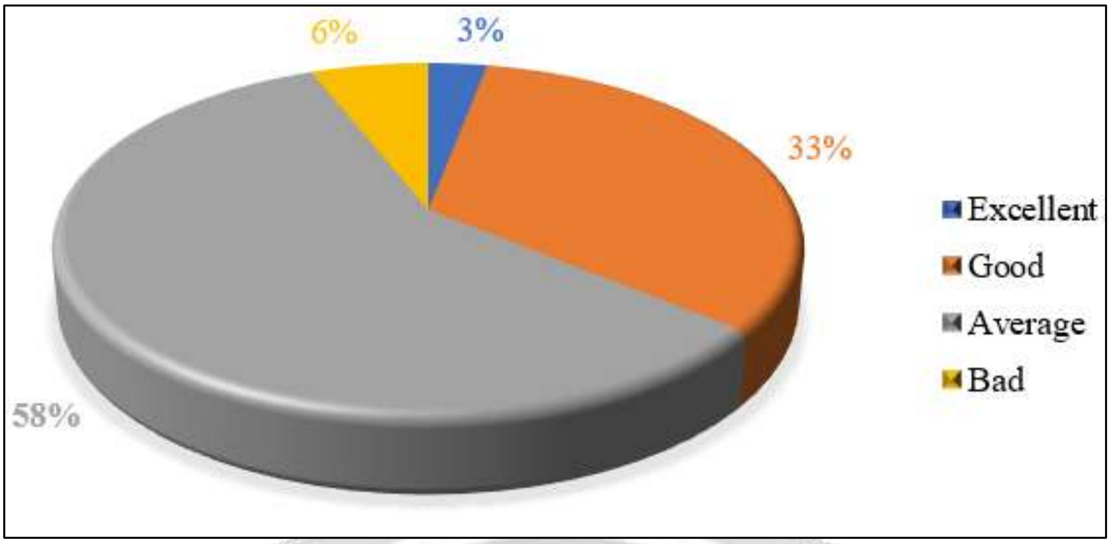


Figure 1: Rating Mwiki railway transport services

5.5 Commuters' Rationale for Using Commuter Rail Services

Close to half (49%) of commuters prefer commuter rail services, since it is traffic jam free; 41.1% choose the mode due to affordability (Ksh. 40), which is half the price charged by other PSVs during peak hours; 4% opt because of safety, since train accidents are rare correlated to road transport; 3% use the train due to its fixed transport cost, KRC charges a constant fee of 40 shillings both to and from Mwiki unlike other modes which hike fares grounding on various factors such as weather; and the remaining 3% choose the mode due to other reasons such as propinquity to the station. **Figure 2** below illustrates the reasons:

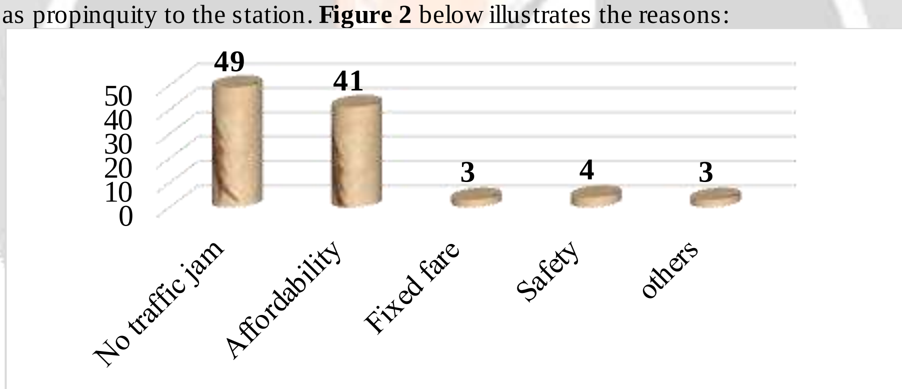


Figure 2: Reasons for using Railway Transport (%)

5.6 Challenges in embracing commuter rail services

The respondents highlighted numerous snags that discourages them in using commuter rail services counting overcrowding within train wagons, lack of instantaneous communication systems, inadequate amenities, poor accessibility to the station, inadequate parking spaces among others.

6 DISCUSSION

6.1 Transportation Systems in the Study Area

Kasarani-Mwiki road (J20_Nairobi) is the major road linking Mwiki to Thika superhighway (A2) and Kangundo road (B63). It is bituminous and habitually experiences traffic congestion ascribed to lack of a designated bus stage and bus stops within the area. A significant number of Matatus make a U-turn at the petrol station opposite Deliverance Road contributing to the regular traffic jam experienced in the area. Besides, stiff competition amid the matatus' drivers prompts them to make turnabouts and precipitous halts in picking and dropping passengers anywhere along the road aggravating the situation. The traffic congestion affects commuters travel time and bus fares. The situation is aggravated in rainy seasons.

6.2 Commuter Rail Services in the study area

The corridor has the highest number of passengers per day compared to the other three existing commuter railway routes namely; Nairobi- Kikuyu, Nairobi-Syokimau, and Nairobi-Embakasi Village corridors. Presently, this route is served by a 24-coach train, which has a capacity of 3168 with 1488 seated and 1680 standing passengers i.e., 62 seated and 70 standing passengers per coach. The train makes two trips in the morning to town and one trip from town in the evening. The first train from Mwiki to town, leaves the station at around 6:40am and reaches Nairobi main railway station at around 7:35am, an average time of 55 minutes. Similarly, a second train departs the station at around 9:20am and arrives at around 10:15am, an approximate time of 55 minutes. As well, the train leaves the main station in Nairobi at 5:40pm and alights in Mwiki at around 18:36pm, taking an approximate time of 56 minutes. From Mwiki to the main railway station in Nairobi, it is approximately 17Km. The train halts for approximately 2 minutes to drop and pick commuters from other two stations amid Mwiki and Nairobi i.e., Dandora and Makadara respectively. The average speed of the train is computed with the formula below;

$$Speed\,(s) = \frac{Distance\ (d)Km}{Time\ (t)h}$$

$$d = 17Km\ (\boldsymbol{google\ earth}, \mathbf{2022})$$
$$T = (Total\ time\ to\ Nairobi\ (55\ minutes) - total\ halting\ time\ (4\ minutes)$$
$$T = (55-4)minutes\ (\boldsymbol{field\ survey}, \mathbf{2022})$$
$$T = 51\ minutes\ \left(\frac{51}{60}h\right)$$
$$Speed\ = \frac{17Km}{\frac{51}{60}\ h}$$
$$Speed\ = 17Km\ X\frac{60}{51}h$$
$$= \mathbf{20}\boldsymbol{Km/h}$$

The train serving Mwiki moves at an average speed of 20 Km/h to its destination. The speed is relatively lower compared other means of transport with an average speed of 80**Km/h** when there is no traffic jam; a range of 60Km/h. Despite the importation of the second hand DMUs in early 2019, the train speed of 20 Km/h is still low though a little higher than the initial train speed of 15Km/h.

6.3 Commuters' Rationale for Using Commuter Rail Services

Among the modal split in Nairobi, the train takes the runt share of less than 1% [31]. Close to half (49%) of commuters prefer commuter rail services, since it is traffic jam free; 41.1% choose the mode due to affordability (Ksh. 40), which is half the price charged by other PSVs during peak hours; 4% opt because of safety, since train accidents are rare and less austere likened to road transport; 3% use the train due to its fixed transport cost, KRC charges a constant fee of 40 shillings both to and from Mwiki unlike other modes which hike fares grounding on various factors such as weather; and the remaining 3% choose the mode due to other reasons such as propinquity to the station.

6.4 Challenges in embracing commuter rail services

Commuters highlighted numerous snags that discourages them in using commuter rail services detailed below;

6.4.1 Overcrowding within train wagons

The train's wagons serving Mwiki area are disproportionate to the number of commuters. Consequently, passengers are congested within the wagons with the mass left standing. Those upright have limited space even to gyrate. Crowding makes commuters susceptible to theft, and sporadically, female commuters nitpicked of anti-social behaviour from decadent men standing behind them in overcrowded wagons. Additionally, they experience poor ventilation due to congestion, and at times commuters with underlying conditions would occasionally black out. Further, inadequate coaches make commuters scramble while boarding the train, thus, they end up losing their valuable and sometimes injured. As well, the commotion, is so unfriendly to people living with disabilities, this makes them to prefer an alternate mode.

6.4.2 Lack of instantaneous communication systems

Lack of instantaneous communication systems channel at Mwiki station, for informing commuters vital info such as train delays and locomotive breakdowns. For instance, passengers would avail themselves at the trains' scheduled time, only to find out it's wanting. They would then opt to use road transport (Kasarani- Mwiki Road). Unfortunately, at this time, the traffic jam would have built up over an extensive stretch to Thika superhighway, the fare would have hiked, and the number of matatus would have declined since they are held in the traffic jam. Because, most people would also be scrambling to embark on the few matatus, it would be difficult for one to board. In the process passengers end up losing their valuable and sometimes injured. This bolsters the inconveniences. Further, they also don't get communication in case of locomotive breakdowns. They realize the train has halted for a while, and are unable to tell their employers or clients their period of delay. Therefore, this makes commuter's railway services unreliable.

6.4.3 Inadequate amenities

The station has only 11 sheltered waiting areas with capacity of 88 sitting spaces. The train capacity of 3168 is underserved with the 88 existing sitting spaces. This discourages passengers from using the train in extreme weathers. As well, the ablution block is indirectly proportional to trains capacity. At times the block will experience crowding when commuters attempt to access the facility at the same time.

6.4.4 Poor accessibility to the station.

Most of the access roads are earthed. Some of sections of the accesses roads to the satiation are generally muddy and flooded during rainy seasons; rendering them impassable. Besides, they are also used as dumping site by residents in their vicinity. This coupled with the muddiness makes commuters to prefer other modes of transport.

6.4.5 Inadequate parking space

The station has only 155 parking lots, disproportionate to the train's capacity, thus impedes park and ride model; where commuters can drive to the station, park their vehicles, board the train to town, and when done with engagements travel back with the train to the station to pick their vehicles and drive home.

7 Conclusion and Recommendation

Transport demand is exponentially increasing parallel to high rate of urbanisation and population increase. Incessant overreliance on road transport in peak hours, will chronically exacerbate the peril of traffic congestion. As well, climate change impacts such as flooding augments traffic congestion in the existing roads, and in some cases leads to temporal closure of some roads. Innumerable attempts to improve the existing roads such as Thika Highway has had trifling effect in cracking the congestion peril. It is time to cogitate other modes of transport. Effective integration of commuter rail services into Nairobi Urban Transportation system is the panacea to this menace. None of the modes in isolation can meet the needs of citizens. However, their integration will be able to address the user needs and motivate them to embrace commuter rail services, and in the process enhance traffic flow in the existing roads. All the snags experienced by citizens while using rail service such as overcrowding within wagons, lack of instantaneous communication systems, poor accessibility to railway stations, unreliability, breakdowns of locomotives, and low train speed; should be tackled so as to enhance their magnetism. To be able to address these hurdles, consorted efforts from KRC, NaMATA, PPPs, KeNHA, KURA, KeRRA, donors, citizens, is necessitated in making the urban transport system more resilient.

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